THE TULIPMANIA: FACT OR ARTIFACT?

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Abstract

The famous tulipmania, which supposedly saw the price of a single tulip bulb rise to the value of a luxury house in 17th century Amsterdam, was an artifact created by an implicit conversion of ordinary futures contracts to option contracts in a largely failed attempt by several Dutch burgomasters to bail themselves out of previously incurred speculative losses in the normal, fundamentally driven, market for Dutch tulip futures.

INTRODUCTION

Whenever economists or economic commentators search the literature for evidence of market instability, bubbles, herd effects, multiple equilibria, or related economic horror stories, they almost invariably point to 17th century Holland's tulipmania. Despite recent attempts to unseat the tulipmania from its place as history's most extreme example of a fundamentally irrational speculative fever,[1] the

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[1]We are referring here to the work of Peter Garber, which has added new light to the study of the tulipmania, In particular, Garber has shown that there are data to support the hypothesis that other bulb markets display price declines that are similar to that possessed by tulip bulbs in early 17th century Holland. In particular, although Garber freely admits that the sudden run-up and partial crash that occurred in the first four months of the tulipmania remains an enigma, he argues that there are 5-year time intervals during which 18th and 19th century hyacinth bulb prices have declined by cumulative magnitudes that are similar to that of the tulipmania. However, reporting a more complete set of data show that the tulipmania crash required much less time than the "comparable" hyacinth price declines.

Thus, if we complete Garber's reported price data by employing his basic data sources, we find that the peak in tulip prices reached in early February 1637 was over **20 times** higher than the prices **both** three months before **and** three months after this peak. The annualized rate of price decline here is not the 38% annual rate of decline that appears in the least stable of his hyacinth markets, but 99.999%! Most importantly, there were no obvious changes in costs or utilities for tulips during this tulipmania, which is why it is widely considered to be a "bubble" rather than merely a reflection of changing market fundamentals.

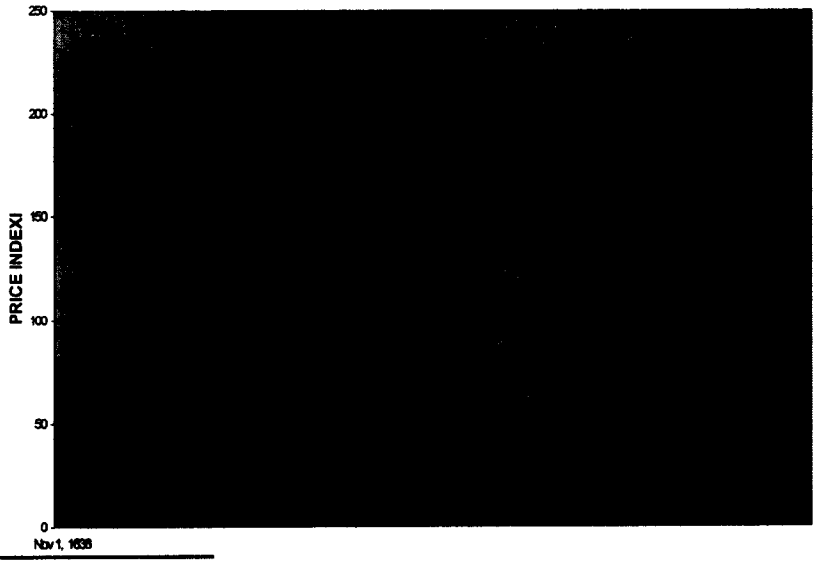
Moreover, Garber's data reveals the existence of some future-delivery-for-cash transactions that were from 1/12 to 1/20 the prices in nearly simultaneous normal futures transactions reported in

undisputed facts remain that -- without any known shocks in either costs or utilities -- the contract price of tulips in early February 1637 reached a level that was about 20 times higher than in both early November 1636 and early May 1637.

I. THE RAW DATA

Figure 1 summarizes the available data on tulip prices with a quality-weighted price index over this time interval. Since the relevant tulip bulbs are regularly planted in the Fall and only dug up in the Spring, the relevant prices here are the prices that appear in contracts for future delivery. Appendix I identifies our sources, all of which are standard, and explains the weighting process. Given the acknowledged absence of basic economic shocks over this relatively short span of time, the unmistakable "bubble" pattern appears to speak for itself.

FIGURE I. THE RAW DATA



more common sources for price data on the tulipmania. We will explain this two-price anomaly in what follows.

Although one might easily infer from Garber's hyacinth argument that flower investors are generally wont to engage in irrational speculative excesses, we shall add support to his efficient-market inference in Section IV below.

II. FACT AND ARTIFACT

However, both the famous popular discussion of Mackay and the famous academic discussion of Posthumus, 1929, point out a highly peculiar part of this episode. In particular, they tell us that, on February 24, 1637, the self-regulating guild of Dutch florists, in a decision that was later ratified by the Dutch Parliament, announced that all futures contracts written after November 30, 1636 and before the re-opening of the cash market in the early Spring, were to be to interpreted as option contracts. They did this by simply relieving the futures buyers of the obligation to buy the future tulips, forcing them merely to compensate the sellers with a small fixed percentage of the contract price. The corresponding option price paid to the sellers was finally, after over a year of negotiation, determined to be only 3½ % of the contract price. The solid-line graph on Figure II, contrasted with the super-imposed broken-line graph of Figure 1, shows the "spot" prices paid to planters who sold tulip futures for cash rather than conditional payments during the "tulipmania." The prices are very close to the Spring spot price of tulips. It is not clear why these authors, and their numerous economic descendants, did not make the appropriate price adjustments and see that the tulipmania was largely a contractual artifact. While it might be argued that expectations were not rational, that the traders were unaware of the conversion of futures to option contracts, Mackay (p. 104-105) emphasizes the public nature of the extensive negotiations over the details of the contract conversions since almost the beginning of the upturn. Moreover, as detailed in the Appendix II, there is a late December contract implying the assertion that if the government converts the contract price to a call-option exercise price, the buyer will have to pay a special fee (a small fraction of the contract price) for the option. These facts rationalize, for most of the tulipmania period, a rational expectations assumption so that the prices that planters expected to receive were the actual prices on the graph rather than the call-option exercise prices represented by the broken line on Figure II.

FIGURE II:COMMONLY EXPECTED, REALIZED AND UNEXERCIZED STRIKE PRICES

III. WHY THE CONTRACTUAL CONVERSION?

As so often happens in economics, answer one question and up pops another. Why did Holland's legislature approve of the buyer-favoring conversion of the contracts? This is especially peculiar in that the policy does not appear to have any significant effect on the spot or expected future tulip prices during most of the tulipmania. We should, of course, proceed backward in time to try to gain some understanding of what the legislature was up to. Figure III displays a broader perspective on tulip prices going back to 1634, which is widely acknowledged to be the first or second year in which the prices of tulips had begun to rise to levels significantly above those of the previous year. Appendix III elaborates on the data sources for this Figure. What we can see from the data is the price of tulips was generally rising throughout this period. The standard literature consistently reports a rather heavy volume, with increased public participation in the boom. Even the Burgomasters were buying. The sellers were mostly professional tulip planters and tenders, people who had been doing quite well in the

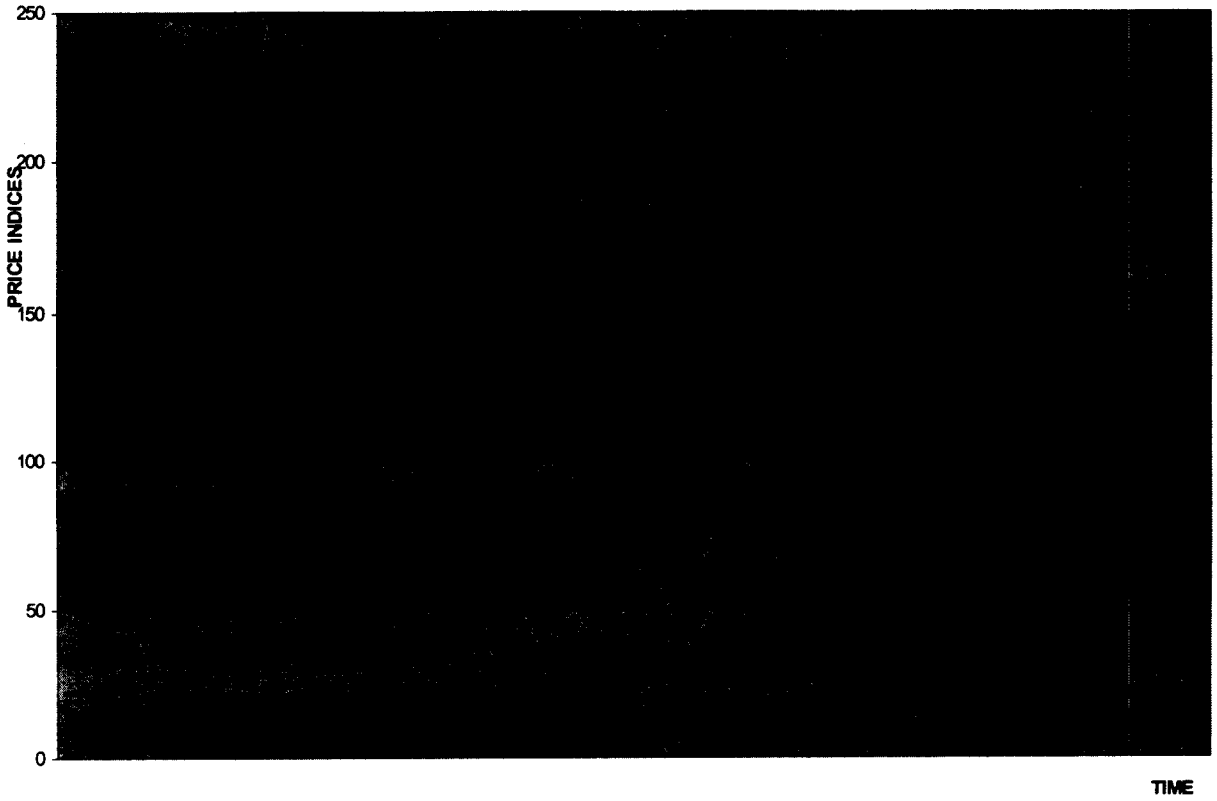
rising mostly professional tulip planters and tenders, people who had been doing quite well in the rising market. But there was a sudden **fall** in the real price of tulips in early November 1636.

Although not integrated into the literature on the subject, the tulipmania was taking place in the middle of perhaps the deadliest war in European history, the so-called "Thirty Years' War." The surprise created by that the events of this lengthy war probably accounted for the price expansion in the early 1630's. For tulips were a recently arrived favorite of the Princes of northwestern Germany, which featured a climate that was exceptionally receptive to the growing of new flowers (see Appendix IV), and the German armies had been steadily pushing back the previously successful Swedes in the early 1630's. Moreover, although peasant revolts had been seriously threatening the northwestern German countryside, and in particular the swarms of tulips grown around the countryside castles, the death in 1632 of Johan Tilly, the leader of the Harz Mountain Rebels, left the Rebels in disarray and thereby greatly expanded the demand for tulips in this important consuming area. Thus, by early 1636, it looked as if the War was winding down in favor of Germany and the peasant revolts were a thing of the past. Although France, apparently in fear of German dominance, had entered the War on the side of Sweden in mid-1635, their early defeats in central France made it appear that the War was basically over It should therefore be no surprise that tulip prices were generally rising at an abnormally high rate during the early 1630's and increasingly so in the late 1635 and early 1636.

However, the newly supported Swedes, in a last stitch effort, resoundingly defeated the Germans at Wittstock in early October of 1636. This shock was followed by renewed German peasant revolts, which thereafter remained an occasionally realized threat for centuries to come. Not only was the prospective German demand for tulips affected, but it now paid the Princes to dig up their tulips, which are usually planted outside the Castle walls and thus very vulnerable to both extended warfare and peasant revolts, and supply them to market for suddenly needed financial support. In view of these

fundamentals, it is no surprise that tulip prices plummeted to 1/7 their October,1936 peak by early November, as can be seen on Figure III.

FIGURE III: TULIP PRICES OVER THE 1634-1637 PERIOD



Although one might be tempted to label this boom and bust the "tulipmania" and forget the later episode, the fact that the price observations followed fundamental shocks should eliminate this idea from consideration. Besides, the tulipmania described in the literature concentrates on the later episode, which begins with the activities of the local Dutch mayors, or Burgomasters.

The early-November investment losses represented a personal financial disaster to several of them. Some heavily margined Burgomasters, as well as many of the middle-class speculators that had joined them, were having their livelihoods threatened at the expense of tulip planters who had already become rich during the extended upturn. So it should not be surprising that the Burgomasters quickly

met with the concerned public after the crash in order to discuss the "problem." The contract conversion was natural to them. After all, they would not have bought the futures contracts if they would have known that price was going to collapse, and the more knowledgeable planters – who probably immediately understood the effect of Wittstock and even hyped the sale of tulip futures in mid-October in order to liquidate their dealer inventories at favorable prices – could afford it. As the information of the Burgomasters' deliberations and plans entered the market in late November, contract prices soared to reflect the expectation that the contract price was now a call-option exercise, or strike, price rather than a price committed to be paid for future bulbs. The contract price would not have to be paid if the future spot price turned out to be less than the contract price. The only cost was that, if the option holders refused delivery, they would have to compensate the planters in their contracts with a small fraction of the contract price.

However, the planters were not totally lacking in political power in the Dutch legislature. So, after lengthy deliberations, while the planters announced that they would indeed accept a reinterpretion of their contracts, chose a later conversion date than the October and November dates that had been suggested by the burgomasters. In particular, the planters announced that they would convert only those contracts that had originated on or after December 1, a date by which it was clear to all traders that the ostensible futures contracts reflected the expectation of a contractual conversion. Despite enjoying the good publicity for coming to accept their speculative losses like good people do, however, the more informed Burgomasters were able to escape the hook. This is because they, being much more informed than anyone else, could liquidate their contracts in late November, when the buyers had already begun treating the contract prices as option strike prices set at around 10 times the actual prices. These Burgomasters even made a tidy profit on their original investments. Indeed, as described in Appendix IV, subsequent records show Burgomasters and their heirs still collecting on these sales contracts decades

after the mania was over.

The above arguments serve to qualitatively rationalize the tulipmania and the critical period that precedes it. We now attempt to quantitatively rationalize these price observations.

IV. THE FUNDAMENTAL VOLATILITY OF THE PRICE OF BREEDING CAPITAL

Suppose a new variety of bulb has been discovered, one whose color is expected to create a generally positive consumers' demand price for the new bulbs of $p(x)$, where x is the accumulated stock of the bulbs. We assume that these final demanders of bulbs are able to breed new bulbs at a rate that will just cover their depreciation through abuse, disease, age, etc., in which case the bulbs represent simple consumer durables. Although we begin with only one bulb, there exist bulb-breeders who can freely reproduce the bulbs at an expected rate of m bulbs per year. The owner of the first bulb can sell for a substantially positive money price, $p(1)$, to the highest demander in the consuming public or to a breeder. A breeder is willing to pay at least $mp(m)/(1+r)$ for the bulb. Since we are not interested in one-bulb markets, we assume that $mp(m)/(1+r) > p(1)$. The breeders compete the price of the bulb in the first period up to the present value of their returns so that

$$p_1^* = mp_2^*/(1+r),$$

where r is the money rate of interest and the asterisk implies that the corresponding variable is at an equilibrium level. If the breeders out-bid the consumers for some of the bulbs in the period 2, the price in the second year is similarly

$$p_2^* = mp_3^*/(1+r).$$

The annual rate of price decline, taken from the lower level, during any breeding era, as can be seen in

the above two equations, is [(m/1+r) - 1]%. This continues on, with the quantity rising each period by mn_t, where n_t is the number of bulbs the breeders compete away from the consumers, until n_t reaches zero because the breeders' demand price is brought down below $p(x)$, which is then the final equilibrium price toward which the earlier prices fall.

If consumers were completely patient, they would rationally wait until the breeders were finished, at which point, the bulbs would begin to sell to the consumers. Production would then accumulate to m to the power of the number of time periods it takes to accumulate enough tulips to drive the demand price down to where an additional bulb could not be sold for a positive price. What impatience does is make the quantity increase at a rate that is slower than the powers of m and the price fall to a level that is so low that even the most patient of consumers is willing to bid the good away from the breeders despite it's large prospective percentage decrease in prices.

In either case, some breeders remain in the market as long as they are willing to pay a higher price than the lowest-positive consumer demand-price in the market, i.e., as long as $mp_t^*/(1+r) > p_T$, where t is a time index and p_T is the lowest positive demand price in the market. And prices will continue to fall at the same substantial rate until this minimum price is hit, at which point all of the breeders are gone from the market and the price is at its minimum level, or p_T^*, at which it will stay forever unless there is a change in market conditions.

Suppose now, beginning in this long run equilibrium, that there is a significant exogenous shock that uniformly reduces the final demand prices for tulips bulbs. This will lower the price from its already extremely low level to zero. Empirically, this is an insignificant price effect. And the shock will have no effect whatsoever on the quantity supplied.

These price and quantity effects of exogenous shocks are much different if the bulb market has

fairly recently opened so that breeders are still active in the market. This certainly characterized the extended period immediately preceding the tulipmania. If, during this extended introductory breeding period, then there is a sudden reduction in demand, say one that will eliminate the last round of breeding, which generally entails eliminating only a few consumers from the market in the realistic case in which there is some impatience, prices will *immediately* decline by $[m/(1+r) - 1]\%$. (This can be graphically seen by shifting a graph of prices over time by one year, thereby hastening the number of years to drive the breeders out of the market by one, and observing that each price decline from the prior level is the slope of the price line, or $[m/(1+r) - 1]\%$ of its later level.) Or if the shock eliminates the final two rounds, similarly eliminating only small numbers of consumers in the realistic case, the price will decline to the square of $m/(1+r)$ of its ultimate level. Hence, if breeders generate a normal annual depreciation rate of 38%, which we might infer from Garber's relatively unstable hyacinth markets, a drop in demand that would reasonably eliminate the last 6 years of bulb breeding would decrease the demand for a high-priced, breeding bulb to $(1/1.38)^6$,or approximately1/7, of its pre-shock level, the effect we actually observed in the fundamental-effected, pre-tulipmania, crash in late October 1636.

Similarly, if, during a breeding phase of a market, demand is observed to rise, thereby cumulatively adding a few rounds of breeding to the market, prices are likely to rise in a similarly sharp fashion in anticipation of these extended rounds. This could easily explain the similarly substantial, good-War-news-based price run-up prior to the bad War news and November crash.

Nevertheless, as we have been stressing, the dramatic apparent price changes that occurred **after** this price cycle, what is conventionally called the "tulipmania," were of much larger magnitude and were not accompanied by similar changes in market fundamentals. We will now attempt to understand the order of magnitude of these latter observed price changes.

V. THE MAGNITUDE OF THE "MANIA"

To more clearly understand the relationship between the nominal, or option-exercise, price on the broken line and real price on Figure 2, consider first what happens to a futures contract when, *cet. par.*, the buyer is suddenly given the option of refusing delivery and keeping his money should the market price of the asset be lower on the planned delivery date than the nominal price on the contract. This price should soar to infinity. Of course, to clear the market, the buyer then should be expected to pay the seller a separate charge for the option. If, however, governmental decree sets this price for the call option at an artificially low percentage of the contract price, the seller must respond by raising the strike price on the call option above the efficient level for an option contract in order to raise the money return and lower the expected money cost of the option until the net rate of return he receives fully compensates him for absorbing the possible capital loss. In this way, the strike price on the option will rise until the return on the option equals its cost. In symbols,

$$1. \qquad rP_c = C + \int_{Pc}^{\infty} pf(p)dp - P_c,$$

where r is the statutory rate the government sets on the option contract, P_c is the exercise price on the option, C is the cost of engaging in the transaction, and f is a probability density of the tulip price distribution function so that the integral in the equation represents the expected price of the asset given that the price exceeds P_c times the probability that the future market price will exceed P_c.

In our case, the rationally expected r is 0.035. To estimate C, the planters' per-bulb transaction costs, note that, from early in the negotiations, the planters position was that they were willing to forgive the buyers their debts for a payment of 10% of the contract price while the Burgomasters were insisting that, dating purchases back to the beginning of October, the buyers of tulip futures had the right to free

options. Assuming, as is customarily rationalized as a best-estimate given our ignorance of such matters, that the total negotiation costs of both buyers and sellers are equal and that the total negotiation costs is ½ of the surplus being fought for, an objective estimate of the seller's part of the special negotiation cost is 1/4 of 10% of the average contract price. Substituting this estimate of C into equation 1, we can write this equation as

2. $$.01P_c = \int_{P_c}^{\infty} f(p)dp - P_c$$

The problem is to solve equation 2 for P_c. Using a log-normal approximation of $f(p)$ and thus following Black-Scholes, we can use numerical methods to solve the equation once we know the standard deviations of the price distribution. Assuming an annual standard deviation of observed tulip price of 33.4, the observed annual standard deviations of tulip prices for the 10 months of 1636 prior to the beginning of the tulipmania in Novermber, this yields a theoretical value of P_c of approximately 180, which is extremely close to the actual average contract price observed during the tulipmania, as can be seen on Figures 2 and 3.

An alternative approach is to check the consistency of the data observed during the tulipmania with data observed in modern options markets. We begin by re-writing equation 1 as:

3. $$P_c = C/.035 + [\int_{P_c}^{\infty} pf(p)dp - P_c]/.035.$$

Since our estimate of C is 1/4 of 10% of the average contract price during the tulipmania, it is approximately ½ of the actual price of corresponding tulip futures. So we write

$$C = (1/2)P,$$

where P is the normal futures price of the asset. Hence, our contract, or exercise, price is

4. $$P_c = [\int_{P_c}^{\infty} pf(p)dp - P_c]/.035 + 14..3P$$

To empirically estimate the bracketed term on the right of equation 4 above, the expected financial cost to the planter from having the customer exercise the option, we perused the actual CBOE prices for 6-month call options of very high volatility stocks that sold for approximately 1/15th of the option's exercise value. We found that such options yielded a price range of .01% to .2% of the contract's exercise price. Using equation 4 above, for such low option prices,, and the average spot bulb index price during the tulipmania of 12.5, a reasonable estimate of the efficient-markets contract, or exercise, price range is 179 to 190. A visual inspection of Figure 2 or Figure 3 reveals that this empirically-based estimate is also an exceptionally accurate estimate of the range of exercise prices observed during the tulipmania.

V. CONCLUSION

A centuries-old literature has misrepresented the "tulipmania." It is not an illustration of what Mackay termed "Popular Delusions and the Madness of Crowds." On the contrary, tulip contract prices before, during, and after the "tulipmania" appear to provide a remarkable illustration of market efficiency. What makes this efficiency so remarkable is that contract prices quickly and accurately reflected the underlying economics of a market in which the emotions of exuberance and depression based upon contemporaneously experienced capital gains and losses might well have been expected to create substantially inefficient price patterns.

APPENDIX I

This appendix explains the process which led to the construction of Figure I above. The raw price data for this time series begins in early November, 1636 with bulbs prices reported in *the Dialogues of Waermont and Gaergoedt.* (Posthumus, 1929, p.453). These dialogues were extremely valuable in creating a reasonably accurate picture of the price movements from early November 1636 to early May 1637, the months during which the tulipmania took place. Indeed, they have been the standard source of tulip price data for the period and have been verified by both Posthumus, 1927, 1929, 1934, and Garber 2000, Appendix A1, through cross-referencing to official notary records.

Given the large implicit differences in relative bulb qualities, an appropriate quality-adjustment was necessary for our general price index to accurately reflect the price movements of the overall tulip market. All standard sources have long recognized P. Cos' Tulip book (1637) as the most useful source of relative tulip prices around the height of the mania. This famous florist's collection of 54 gouaches is now particularly valuable as the only of its kind to systematically record the weight and price at which each bulb depicted inside the catalog was sold at the beginning of 1637, thus allowing us to almost perfectly capture the relative value of many bulbs. Calculating a price for each type of bulb in terms of guilders per aas (about 1/564th of an ounce), and interpreting these newly found relative prices as relative quality measures, allowed us to eliminate the enormous quality distortions in what otherwise would have been an unweighted price index. The result was the price index for a standardized tulip bulb depicted in Figure I.

The first prices reported in the *Dialogues* were a series of four prices in early November, whose index values were very similar and whose average value we display on the Figures as the realized bulb prices running from November 1 through November 10. Consequently, the first series of prices on Figures I and II reflect these sales and their average price. More specifically, the *Dialogues* indicate that

several bulb sales occurred immediately after the end of the planting season , which would have put these sales in approximately the first 10 days of November. The prices for several bulbs such as two Gel en Rot van Leijen (46 guilders for a 515-aas bulb and 100 guilders for a 1,000 aas bulb, or an average of 0.9 guilders per aas), and two Admiral De Man (a 130-aas bulb for 15 guilders and a 1,000 aas bulb for 90 guilders, or an average of approximately 0.1 guilders per aas) yielded adjusted average index values of, respectively, 10.2 and 7.7, for an overall average index value of 8.9.

Waermont and Gaergoedt then report that on November 12, 1636, according to the broker's record, a 375-aas Ghemarmerde de Goyer was exchanged for the price of 70 guilders, or an index value of 10.5. This and related transactions will be discussed further in Appendix II.

The next value is taken from the November-25 trade of a Gouda weighing 66 aazen which exchanged for 446 guilders (Garber, p.139), or 6.76 guilders per aas, representing an index value of 97.

Next, the Dialogues report that on or about December 1, 1636, the respective exchange prices for a Gheele en Root van Leyden and a Admirael de Man were 1.2 guilders per aas (index value of 122) and 1.35 guilders per aas (index 94), representing an arithmetically averaged index level of 108. While the precise dates of these transactions are unknown, Gaergoedt, a professional tulip broker, refers to the exchanges as taking place "about a month after" the sales reported at the beginning of November (Posthumus, 1926, p. 42).

Then on December 12, a Gouda is reported to have been contracted for 10.83 guilders per aas, which represents an index value of 176 (Posthumus, 1929, p.456).

After this date, the direction of the trend in the price of tulips remains undisputed by all traditional sources. Contract prices rose to new heights until word of a trading suspension reached the traders on February 2nd and 3rd (Posthumus, 1929, p.444), after which prices sagged until the actual suspension of trading at the market center at Alkmaer on February 5th 1637.

It has been accepted that February 5, 1636 was almost certainly the day the tulip trade was first suspended. Many trades were recorded on that day. Unfortunately, there is no information pertaining to the order in which the sales took place throughout the day. So the only sensible response, we must agree with most of our predecessors (Garber's graphs, probably for dramatic purposes, reported only a highest observed price on that date), is to compute an average and accept it to be the price level for February 5. The *Dialogues* (Posthumus, 1927, pp. 43 - 44) report 7 Gouda trades on this date. Their prices are, in terms of guilders per aas, 7.47, 8.12, 9.32, 10.08, 56.25, 3.6, 6.14 and 7.11, or, respectively, index values of 122, 132, 152, 164, 916, 58, 100 and 116. The Dialogues and Krelage report 5 trades of Gel en Rot van Leijen bulbs. These bulbs sold for .7, .35, 1.06, .58 and .979, or respective index values of 71, 36, 108, 59 and 100. Averaging all these index values comes out to be a February 5 price index value of 178.

The enormous variation in prices on February 5 can be understood by recognizing that markets were closed down at different times. By far, the largest market, which was in Alkmaer, was the first to be closed down. Traders in the secondary markets, suddenly aware that their trading opportunities would also end shortly and that they no longer could use the Alkmaer market for arbitrage, were thus put into either highly monopolistic or highly monopsonistic market settings. In such settings, it is perhaps not surprising that prices would jump to an index value of 916, over 3 times the average price of the now-illegal contracts, or fall to an index value of 58, less than 1/3 of the average. Indeed, while the price variation in the 10 February 5th trades occurring in Alkmaer was not exceptionally large, of the above noted pair of February 5th outliers, the high price occurred in Haarlem and the low one in an unspecified outside hinterland location.

Since price data is strangely sparse in the long period between December 12 and February 5, we could not, from the bulbs in our index, measure the magnitude of the decline in bulb prices just prior to the price decline in early February. To gain some idea of the magnitude of this decline, we noted that there

were some prices available for a relatively low quality bulb, called a "Switser," even though these prices did not appear in our index because Cos did not deal in these bulbs. Krelage (p.51)presents Switser price data for several days in early February, which allowed us to link Switsers to our price index. The resulting index numbers are 199 for February 1, 202 for February 3, 178 for February 5, when we had both Switser and non-Switser prices available so as to link the two series together.

In fact, trading continued in the secondary markets in Haarlem and Amsterdam for several days after February 5. Krelage (p, 52)reports a price for one pound of Switsers at 1,100 guilders in a trade on February 9th. The corresponding index value is 148. Posthumus (1934, p. 234-5) reports two February 11 contracts written in Amsterdam in which four different one-pound packages of Switsers were sold, respectively, for 1,060, 1,065, 1,100, and 1,100 guilders. This yields an average index value of 145.

Finally, we gain some new perspective on the post-tulipmania market price for bulbs as Gaergoedt describes a large-volume cash transaction dated of May 1, 1637. At that point, the broker details the sale of many bulbs, including, among others, a Gel en Rot van Leijen, sold for 22 guilders when, "if they had been sold at the moment of highest price in the winter, they would have made over 400 guilders; at least they would have been promised for it" (Posthumus, 1929, p.459). This price reveals that in the spring of 1637, contract prices were worth only slightly more than 1/20th of their all-time high value, thus giving us a May-1 index value of 11, this value being representative of the actual magnitude of the "tulipmania" between early February and early May 1637. The above-noted discussion of Gaergoedt of the weeks following the May 1st trade make it clear that the market was basically unchanged during the month of May.

Appendix II

Figure II introduces other kinds of bulb prices observed during the period stretching from

November 12, 1636 to May 1637. Although many of these prices often fall within a few days of those reported in Appendix I, most of them are an order of magnitude lower than the Appendix I prices. Waermont and Gaergoedt discuss, on page 456, a sale that took place on November 12, 1636. According to Waermont's record, a 375-aas Ghemarmerde de Goyer was exchanged for the price of 70 guilders, an index value of 10.5. A careful reading of the trader's records should clarify the atypical nature of this low-price transaction. While the price and weight of the bulb are succinctly recorded, there is no mention of any further obligation on the part of the buyer, no alternative means of future payment, and no schedule of future payment. Indeed, the ledger was signed solely by the seller, clearly indicating that the only future obligations belonged to the seller. This transaction must therefore have been a cash transaction. The only liability it imposed was a promise of delivery on the part of the seller in the middle of the next spring, as the bulbs are dug up from the ground and physically delivered to the purchaser.

Similarly, on the 9th of December, Posthumus (1929, p. 456) reports the sale of a Gel en Rot van Leijen for the apparently surprising low price of 70 guilders for a 578-aas flower, or an indexed value of 12.2. Here again, as it was for the November 12th transaction above, the broker's book is signed only by the seller since the sale is a cash transaction reflecting the true futures price of the bulb in question. Indeed, that later sale, the following entry in Gaergoedt's records, displays an altogether different type of transaction in that, unlike the December-9th sale which was succinctly recorded and signed only by the seller, the later sale has both the seller and the buyer sign the transaction record and identifies the buyer's alternative means of payment in case cash is not delivered in the future.

By mid-December, the nature of the call option contract must have been widely understood by the traders. Indeed, Dash describes in detail a deal made toward the end of December 1636 which plainly defines the terms of the option as a planter "Henricus Munting was able to complete a lucrative deal to sell a handful of his tulips for 7000 guilders to a man from Alkmar only by promising his nervous customer

that if prices fell before the summer of 1637 he could cancel the purchase and pay no more than 10 per cent on the agreed price" (p.176).[2]

APPENDIX III

Figure III above puts the "mania" in perspective by looking at the evolution of the Dutch tulip market over the two-year period which led to the Tulipmania. The earliest prices from December 1634 to July 21st, 1636 are to be found in Krelage. On page 49 and 50, he mentions Gouda prices in December 1634 at 30 stuivers per aas (or 1.35 guilders per aas), which represented an index 22. The next Gouda is priced at 2.1 guilders per aas (index 34) during the winter of 1635/36. In May 1636, Krelage lists bulbs of the same variety being exchanged for 3.75 guilders per aas, thus yielding an index value of 61. Then, the discussion moves to an Admiral Liefken been sold in June 1636 for 6 guilders and 12 stuivers per aas, or an index value of 38. A bulb of Admiral van der Eijck was sold at 2 guilders and 10 stuivers on July 21st, 1636, giving us an index value of 51. By the closing of the summer 1636, on August 29, the prices have again

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[2]We excluded two kinds of price observations. One was a very high per-aas price, extremely small, 7 aas Gouda. The other, low-price Switsers that traded early in the mania, before these bulbs came to attract speculative interest.

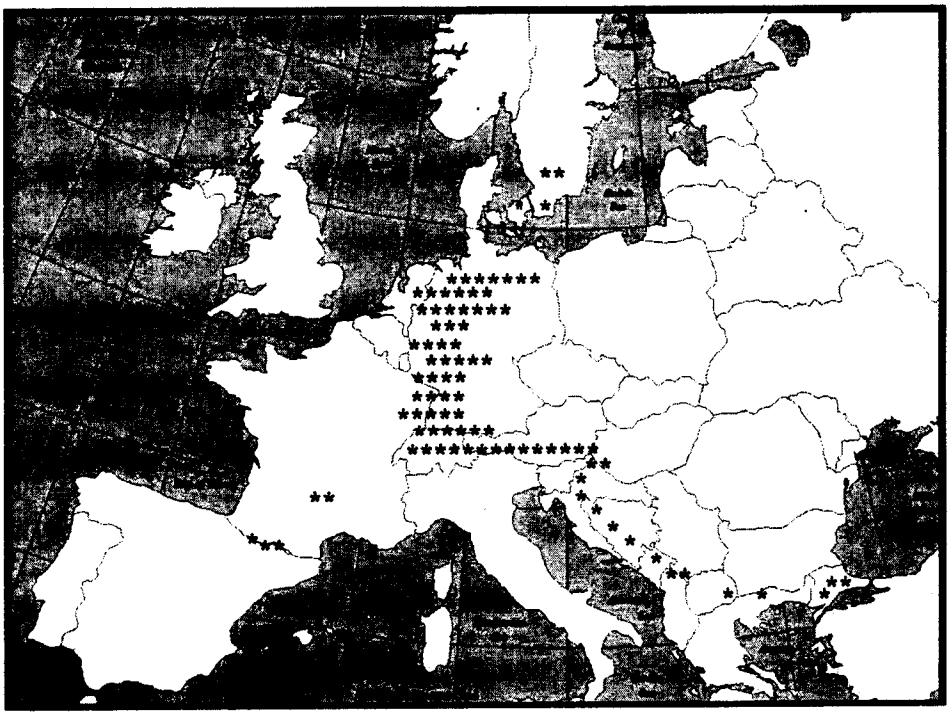
Regarding the former, Posthumus (1927, p.41) describes a January 29th, 1637, sale to a baker from Haarlem of a 7-aas Gouda for the contract price of 100 guilders. Although this represents a sale at 14 guilders per aas, or an unadjusted index value of 228, such a small bulb would probably, in just a year become at least a 200 aas bulb with the proper amount of nurturing and care. The other bulbs in our index were at least 200 aazen. Ignoring the prospective cost of care, risk, and interest, the contract price would have been around 2,000 guilders. To make this baby bulb comparable, we would have add the prospective care, risk, and interest costs to the 100 guilders price and then compute a per-aas price as if the small bulb actually weighed 200 aazen, in which case the per-aas price would have been a lot lower than 14 guilders. So the price should have probably been adjusted downward to account for the small size of the bulb. However, if we adjusted it down by more than 15%, we would contradict the statements of Posthumus (1929, pp. 444, 455) and essentially all others that contract prices were rising in late December and January and declined from their peak during the three days preceding the February 5th suspension. We would also contradict the February 1 index value of 199. Having no real grounds for the 15% discount, we simply omitted the observation from our sample.

Regarding the low-priced Switsers, the inferior status of these bulbs as a speculative asset is indicated not only by their absence from Cos' tulip catalogue despite their great abundance but also by the fact that, prior to the tail end of the mania, sales were in heterogenous pound lots whereas sales of the speculative quality bulbs were on a per-bulb basis (Posthumus, 1929, p 454).

risen, reaching the index value of 61, as we see, in Garber (2000, p139), a Gouda being sold for 3.75 guilders per aas.

APPENDIX IV

The following map shows the areas of the European continent that have been traditionally accepted to be prime tulip growing regions (*Tulipworld.com*), from the first bulbs' birthplace in Constantinople to their European springboard inVienna to the propitiously cold plains of Western Germany (Dash, Chapter 1).



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Tulipworld.com, Planting and Care/Climate Zones. Currently, the web address is: http://www.tulipworld.com/tulip.asp?contentloc=/info/bulbcare/climatezone.shtml

December 31, 2002